The T-ρ coexistence curve of nuclear matter: EOS results

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In Fisher's droplet model [1] a non-ideal fluid is approximated by an ideal gas of droplets. Thus, summing over An_A, the normalized yield of droplets of size A multiplied by A, gives the density and the reduced density is:

$$\frac{\rho}{\rho_c} = \frac{\sum An_A(\Delta\mu, E_{Coul}, T)}{\sum An_A(\Delta\mu, E_{Coul}, T_c)}. \quad (1)$$

With $\Delta\mu$ and E_{Coul} set to 0 in the numerator and $\Delta\mu$ and E_{Coul} set to 0 with T set to T_c in the denomenator, Eq. (1) gives the vapor branch of the coexistence curve of finite nuclear matter. Figure 1 shows the results from an analysis of the EOS fragment yields of 1 AGeV Au, La, Kr + C [1].

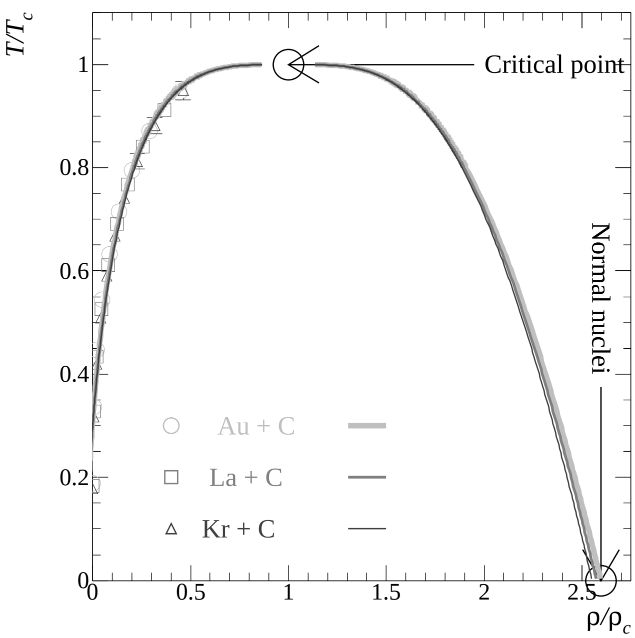

Figure 1: The points are calculations performed at the excitation energies below the critical point and the lines are a fit to and reflection of Eq. (2).

Following the work with simple fluids it is possible to determine the liquid branch as well: empirically, the ρ/ρ_c-T/T_c coexistence curves of several fluids can be fit with the function:

Table 1: EOS critical point values

	T_c (MeV)	ρ_c (ρ_0)	p_c (MeV/fm^3)
Au	7.6 ± 0.2	0.39 ± 0.01	0.11 ± 0.04
La	7.8 ± 0.2	0.39 ± 0.01	0.12 ± 0.04
Kr	8.1 ± 0.2	0.39 ± 0.01	0.12 ± 0.04

$$\frac{\rho_{l,v}}{\rho_c} = 1 + b_1(1 - \frac{T}{T_c}) \pm b_2(1 - \frac{T}{T_c})^{\beta} \quad (2)$$

where the parameter b_2 is positive (negative) for the liquid ρ_l (vapor ρ_v) branch. Fisher's droplet model gives $\beta = (\tau - 2)/\sigma = 0.3 \pm 0.1$ for this work [1]. With this value of β, fitting the coexistence curve with Eq. (2) gives a estimate of the ρ_v branch of the coexistence curve and changing the sign of b_2 gives the ρ_l branch, thus yielding the full T-ρ coexistence curve of finite nuclear matter.

Assuming that normal nuclei exist at the $T = 0$ point of the ρ_l branch of the coexistence curve, then using the parameterization of the coexistence curve in Eq. (2) gives ρ_c in Table 1.

The critical compressibility factor $C_c^F = p_c/T_c\rho_c$ can be determined from:

$$C_c^F = \frac{\sum n_A(\Delta\mu, E_{Coul}, T_c)}{\sum An_A(\Delta\mu, E_{Coul}, T_c)}. \quad (3)$$

Performing these sums with $\Delta\mu$ and E_{Coul} set to 0 with T set to T_c gives $C_c^F = 0.3 \pm 0.1$ which agrees with the values for several fluids. Using the EOS T_c values [1] and ρ_c from above in combination with C_c^F gives a critical pressure, also shown in Table 1.

References

[1] J. B. Elliott *et al.*, to be submitted to Phys. Rev. C (2002).